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Forest Health Protection

Pacific Southwest Region

Northeastern California Shared Service Area

Date: September 8, 2016
File Code: 3420

To: District Ranger, Beckwourth Ranger District, Plumas National Forest

Subject: Evaluation of stand conditions for the Plumas Eureka Project (FHP Report NE16-11)

Summary

At the request of Paul Czeszynski, Silviculturist, Beckwourth Ranger District, Danny Cluck, Forest Health Protection (FHP) Entomologist conducted a field evaluation of the Plumas Eureka project on August 15, 2016. The objective of this visit was to evaluate the current forest health conditions within the proposed project area, discuss what influence these conditions would have on stand management objectives, discuss the use of the 2014 Farm Bill categorical exclusion and provide recommendations as appropriate.

Key findings:

- Mixed conifer stands have become extremely dense with a higher proportion of white fir and Douglas-fir in the absence of fire.
- Ponderosa and Jeffrey pine stands are well above recommended stocking levels for reducing the risk of bark beetle-caused mortality.
- Many stands have experienced elevated levels of tree mortality during the current and recent droughts.
- High fuel loads, consisting of an abundance of dead-down trees and a dense understory of live trees have put many stands at risk to stand replacing wildfire.
- Thinning is highly recommended throughout the Plumas Eureka Project area to reduce the risk of bark beetle-caused tree mortality and reduce fuels.
- This report supports the use of the Farm Bill Categorical Exclusion to accomplish density reduction treatments within the proposed project area.

Description of the project area

The Plumas Eureka project is adjacent to the communities of Blairsden and Graeagle, CA at elevations ranging between 4,300 and 5,000 feet (39.790439N and 120.649599W). Annual precipitation ranges between 30 and 60 inches (Figure 1). Sierra mixed conifer is the predominant

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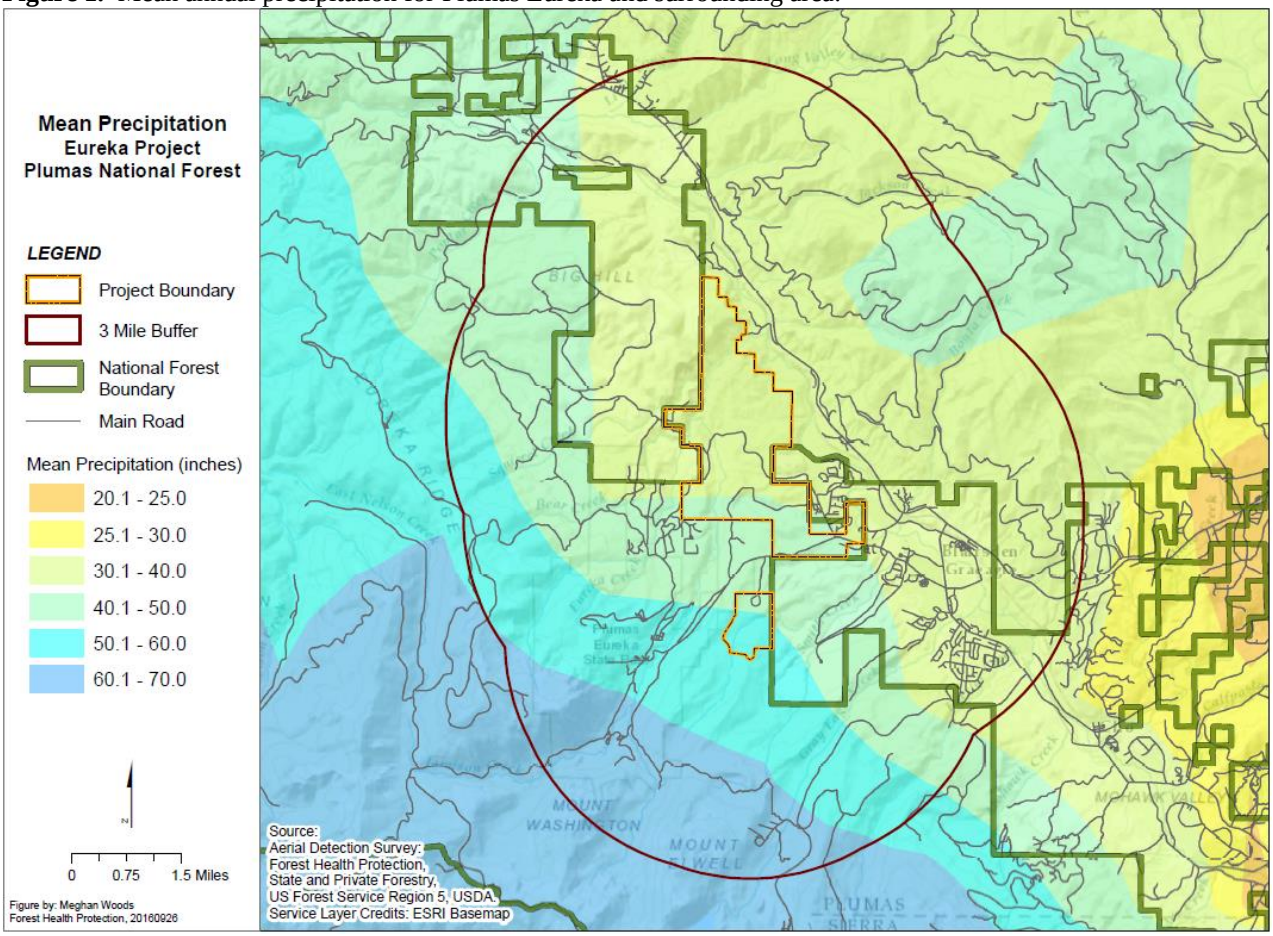
forest type in the project area with ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*Pinus jeffreyi*), Douglas-fir (*Pseudotsuga menziesii*), incense cedar (*Calocedrus decurrens*), and white fir (*Abies concolor*). Lower elevation and generally drier areas are dominated by eastside pine stands consisting of ponderosa and Jeffrey pine.

Figure 1. Mean annual precipitation for Plumas Eureka and surrounding area.



Project objectives

The Plumas Eureka project proposes to improve forest health through tree density and hazardous fuels reduction. The residual stands will be more open, increasing the amount of available soil moisture and sunlight for individual trees, and contain fewer white fir and Douglas-fir. This project will increase the resiliency of treated stands to bark beetles. The project will be accomplished using the 2014 Farm Bill categorical exclusion.

Forest insect and disease conditions

Agents/hosts observed:

- Western pine beetle (*Dendroctonus brevicomis*)-caused mortality of ponderosa pine
- Jeffrey pine beetle (*Dendroctonus jeffreyi*)-caused mortality of Jeffrey pine
- Fir engraver beetle (*Scolytus ventralis*)-caused mortality of white fir
- Black stain root disease (*Leptographium wageneri* var. *pseudotsugae*) in Douglas-fir

Stand conditions and mortality related to recent and future climate trends

Most of the forested areas within and adjacent to the Plumas Eureka project area are in an extremely overstocked condition and in drier years have exhibited an elevated level of tree mortality caused by bark beetles (Table 1 and Figures 2 & 3). This mortality combined with high stand density has resulted in heavy fuel loading in some areas and a corresponding increase in fire danger.

Figure 2. Areas and number of years with mapped tree mortality within and adjacent to the Plumas Eureka project area.

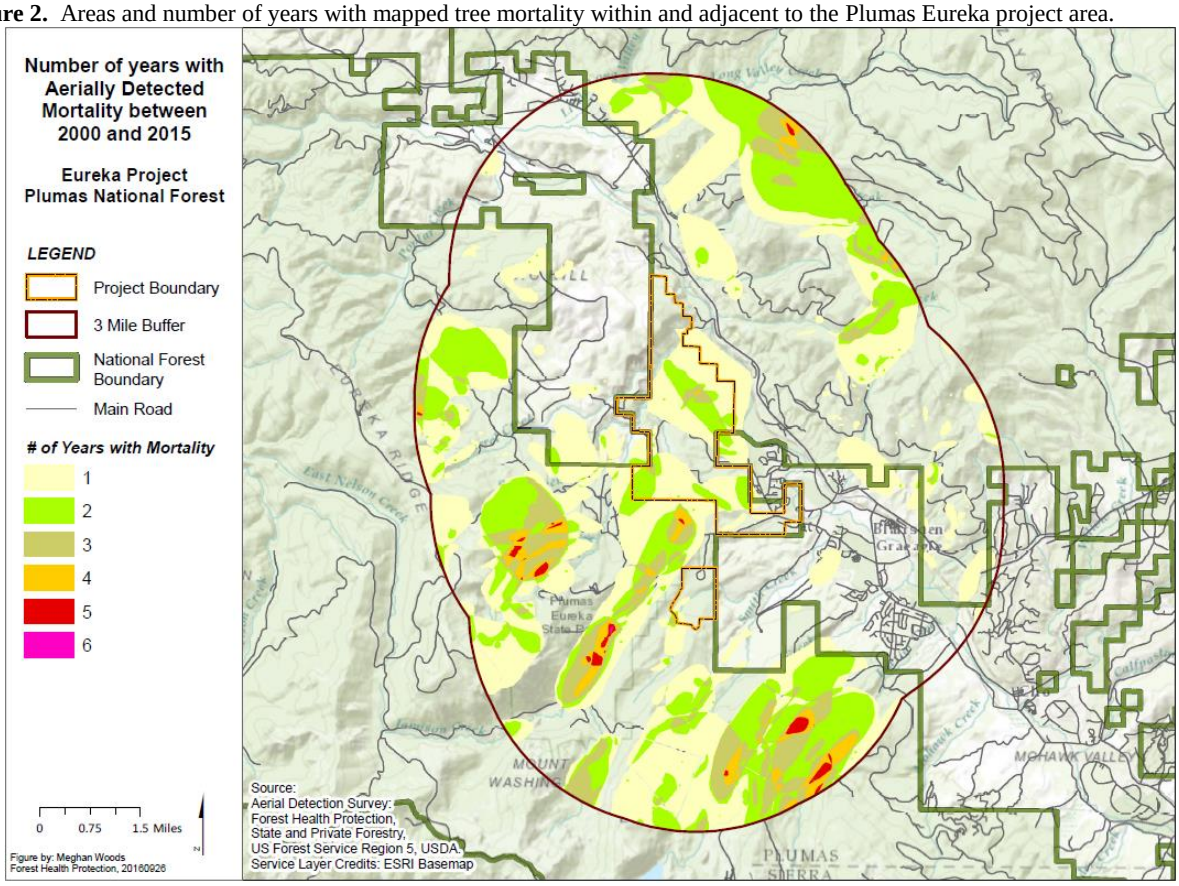
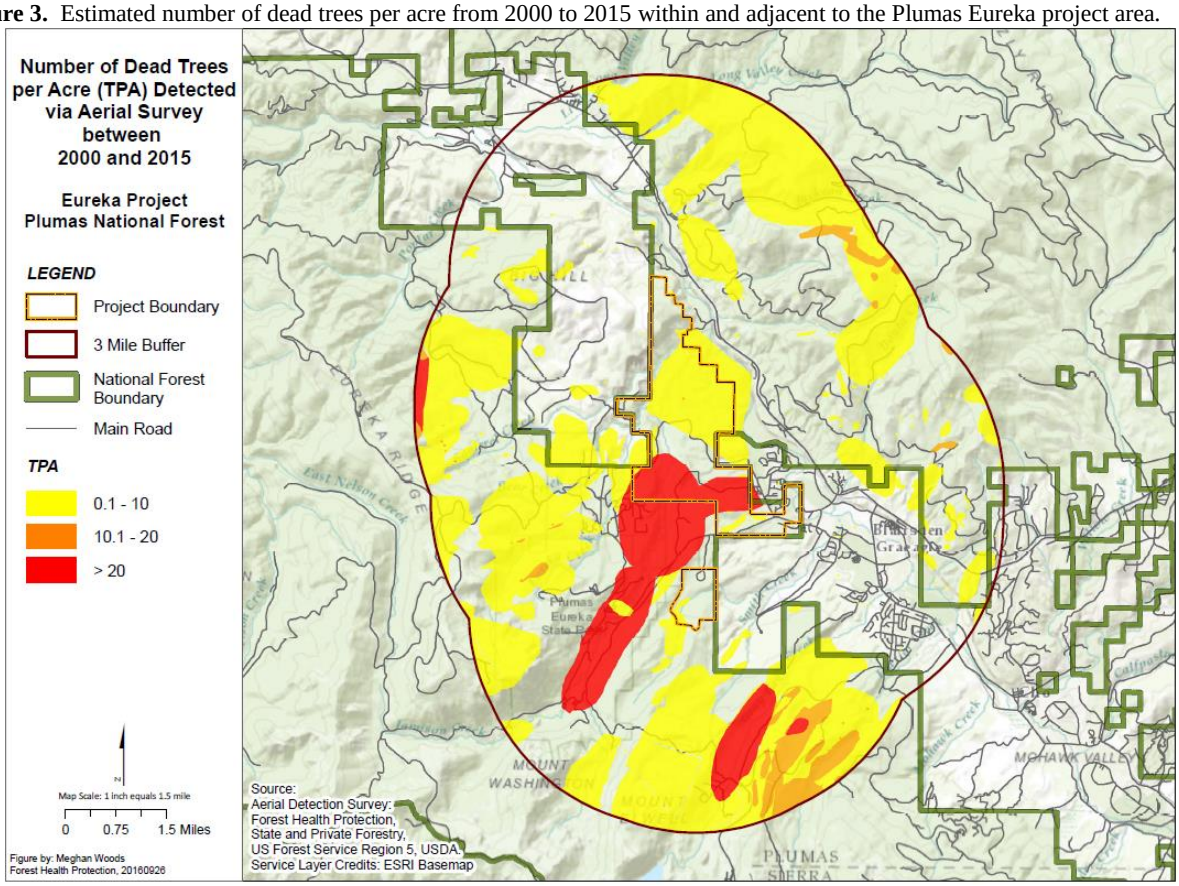


Table 1. Acres with mortality, estimated dead trees per acre and estimated total # of dead trees from R5 Aerial Detection Surveys and Palmer Hydrologic Drought Index (PHDI) (average of CA Divisions 2 and 3[1]) by water year (Oct-Sept) within and adjacent to the Plumas Eureka project area.

Year	Acres	Dead Trees/Acre	Total # of Dead Trees	PHDI[2]
2015	1,224	2.0	2,462	-3.34
2014	85	0.8	69	-3.56
2013	93	1.2	115	-2.16
2012	1,255	1.9	2,434	-0.59
2011	366	1.2	447	2.78
2010	3,822	2.8	10,688	-0.14
2009	780	3.4	2,642	-2.98
2008	80	1.3	102	-3.16
2007	309	1.8	564	-3.17
2006	156	1.5	229	2.40

[1] California Divisions 2 and 3 encompass most of northeastern California. Plumas Eureka is on the border between these two zones.
[2] PHDI values ranging from -2.00 to -2.99 are considered moderate drought conditions. Severe drought conditions range from -3.00 to -3.99 and extreme drought conditions are below -4.00.

Figure 3. Estimated number of dead trees per acre from 2000 to 2015 within and adjacent to the Plumas Eureka project area.



The current trend in most Plumas Eureka stands of increasing stand density, high levels of insect and disease activity and elevated levels of mortality are likely to continue until a major disturbance event such as a stand replacing fire occurs. Bark beetle activity is likely to increase in response to extended drought periods.

Predicted climate change is likely to impact trees growing in this area over the next 100 years. Although no Plumas National Forest specific climate change models are available at this time, there is a general consensus among California models that summers will be drier than they are currently. This prediction is based on the forecasted rise in mean minimum and maximum temperatures and remains consistent regardless of future levels of annual precipitation (K. Merriam and H. Safford, *A summary of current trends and probable future trends in climate and climate-driven processes in the Sierra Cascade Province, including the Plumas, Modoc, and Lassen National Forests*). Under this scenario, the risk of bark beetle-caused tree mortality will likely increase for all conifer species, especially drought intolerant white fir. Improving the resilience of stands to future disturbance events through density, size class and species composition management will be critical to maintaining a healthy forested landscape.

Considerations for thinning treatments

The proposed thinning treatments for the Plumas Eureka project should effectively reduce inter-tree competition for limited water and nutrients and reduce the risk of insect and disease-caused mortality. In most cases, thinning to a relative density of 25 - 40% (relative to the maximum Stand Density Index, or SDI) for a specific conifer species or for a weighted composition of conifer species will effectively reduce competition for limited water and nutrients and reduce the

susceptibility to future bark beetle-caused tree mortality. For the Plumas Eureka project area, the District should consider basing relative density targets on the pine component of mixed conifer stands. For eastside pine stands, the District should consider using the bark beetle limiting SDI of 365 as a basis for thinning prescriptions. SDI 365 is considered the upper management zone above which bark beetle outbreaks are likely to occur and SDI 230 is considered the threshold for the zone of imminent bark beetle caused mortality. Within this zone, endemic populations kill a few trees but net growth is still positive (Oliver 1995). Planning thinning treatments that result in stocking levels well below SDI 230 would greatly reduce the risk of bark beetle caused mortality in these areas. These types of prescriptions would be consistent with 2014 Farm Bill Section 602(d)(1) direction that allows the implementation of projects "….to reduce the risk or extent of, or increase the resilience to, insect or disease infestation in the areas."

When planning thinning treatments, it should be recognized that the target stand density is an average to be applied across the landscape and some variability may be desired. Individual high value trees, such as mature pines, and drier areas dominated by ponderosa and Jeffrey pine should benefit by having the stocking around them reduced to lower levels. Allowing for denser tree spacing and pockets of higher canopy cover may be desirable around potential wildlife trees, such as forked and/or broken-topped trees. Incorporating the concepts of GTR 220 will address many of these issues and be consistent with Region 5 ecosystem restoration goals. Many of these methods are also consistent with past Forest Health Protection recommendations for thinning in eastside pine and mixed conifer stands and their use is supported for the Plumas Eureka project.

It is recommended that a registered borate compound be applied to all freshly cut ponderosa pine, Jeffrey pine, incense cedar and white fir stumps >14" in diameter to reduce the chance of creating new infection centers of *Heterobasidion irregulare* and *H. occidentale* formerly referred to as P-type and S-type annosus root disease, through harvest activity. It is not necessary to treat Douglas-fir stumps as Douglas-fir has a low susceptibility to Heterobasidion root disease.

The pocket of black stain root disease found in Douglas-fir during this trip is uncommon for the area and a single isolated pocket would not generally be a serious management concern. However, due to the proximity of this root disease pocket to the public water supply tank and access road, ongoing tree mortality is creating a potentially hazardous condition and special treatment should be considered. This could include removing all Douglas-fir from within and adjacent to the known infected area or thinning to wider spacing to allow Douglas-fir to better cope with the disease. Please refer to the black stain root disease information at the end of this report for management details. The District should also map any additional black stain root disease pockets in Douglas-fir encountered in the area for future reference and management.

If you have any questions regarding this report and/or need additional information please contact Danny Cluck at 530-252-6431.

/s/ Danny Cluck

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Insect and Disease Information

Western Pine Beetle

The western pine beetle, *Dendroctonus brevicomis*, has been intensivly studied and has proven to be an important factor in the ecology and management of ponderosa pine thoughout the range of the host species (Miller and Keen 1960). This insect breeds in the main bole of living ponderosa pine larger than about 8 inches DBH. Normally it breeds in trees weakened by drought, overstocking, root disease, dwarf mistletoe or fire. Adult beetles emerge and attack trees continuously from spring through fall. Depending on the latidude and elevation, there can be from one to four generations per year.

Evidence of Attack

Initial attacks are made about mid-bole and subsequent attacks fill in above and below. Pitch tubes are formed on the tree trunk around the entry holes. Successful pitch tubes are red-brown masses of resin and boring dust. Relativly few, widely scattered white pitch tubes usually indicate that the attacks were not successful and that the tree should survive. Pheremones released during a successful attack attract other conspecifics. Attracted beetles may then spill over into nearby apparently healthy trees and overwhelm the tree with sheer numbers.

Life Stages and Development

These beetles pass thorugh the egg, larval, pupal and adult stages during a life cycle that varies in length dependent primarily on temperature. Adults bore a sinuous gallery pattern in the phloem and the female lays eggs in niches along the sides of the gallery. The larvae are small white grubs that first feed in the phloem then mine into the middle bark where they complete most of their development. Bluestain fungi inoculates the tree during successful attacks, blocking trachids and vessicles which contribute to the rapid tree mortality associated with bark beetle attacks.

Conditions affecting Outbreaks

Outbreaks of western pine beetle have been observed, and surveys made, in pine regions of the Westsince 1899 (Hopkins 1899; cited in Miller and Keen 1960). An insect survey completed in 1917 in northern California indicated that over 25 million board feet of pine timber had been killed by bark beetles.Information from surveys conducted in the 1930's indicated enormous losses attributed to the western pine beetle around that time. During the 1930's outbreak, most of the mortality occurred in stands of mature or overmature trees of poor vigor (Miller and Keen 1960). Group kills do not typically continue to increase in size though successive beetle generation as is typical with Mountain Pine Beetle and Jeffreay Pine Beetle. Rather, observations indicate that emerging beetles tend to leave the group kill area to initiate new attacks elsewhere.

The availability of suitable host material is a key condition influencing western pine beetle outbreaks. In northeastern California, drought stress may be the key condition influencing western pine beetle outbreaks. When healthy trees undergo a sudden and sever moisture stress populations of western pine beetle are likely to increase. Healthy trees ordinarily produce abundant resin, which pitch out attacking beetles, but when deprived of moisture, stressed trees cannot produce sufficient resin to resist the attack. Any condition that results in excessive demand for moisture, such as inter-tree completion, competing vegetation, or protracted drought periods; or any condition that reduces the ability of the roots to supply water to the tree, such as mechanical damage, root disease or soil compaction, can cause moisture stress and increase susceptibility to attack by the western pine beetle. Woodpeckers, predacious beetles, and low temperatures act as natural control agents when beetle populations are low (endemic populations).

Jeffrey pine beetle

The Jeffrey pine beetle is the principle bark beetle found attacking Jeffrey pine, which is its only host. It is a native insect occurring from southwestern Oregon southward through California and western Nevada to northern Mexico. The beetle normally breeds in slow-growing, stressed trees. The beetles prefer trees which are large, mature, and occur singly rather than in groups. Yet when an epidemic occurs, the beetle may attack and kill groups of trees greater than 8 inches in diameter, regardless of age or vigor. Often the beetle infests lightning-struck or wind-thrown trees, but does not breed in slash.

Evidence of Attack

Presence of the beetle is usually detected when the foliage changes color. The color change of the foliage is related to the destruction of the cambium layer by the beetle. Generally, the top of the crown begins to fade in a slow sequence, with the needles turning from greenish yellow, to sorrel, and finally to reddish brown. By the time the tree is reddish brown, the beetles have usually abandoned the tree. Another sign of beetle attack is large, reddish pitch tubes projecting from the bark of the infested tree. If examined carefully, pitch tubes can be detected on infested green trees prior to crown fade. Jeffrey pine beetles have a distinctive "J" shape egg gallery pattern on the inner bark. Larval mines extend across the grain and end in open, oval-shaped pupal cells.

Life Stages and Development

The Jeffrey pine beetle is one of the larger pine bark beetles in California. The beetle has a 4 life stages, egg, larva, pupa, and adult. The adults are stout, cylindrical, black, and approximately five-sixteenths of an inch long when mature. The egg is oval and pearly-white. The larva is white, legless, and has a yellow head. The pupa is also white but is slightly smaller than the mature larva. The life cycle is normally completed in one year in the northern part of the range, but in the southern part, two generations per year may occur. The principle period of attack is in June and July, but attacks also are frequent in late September and early October. Similar to other *Dendroctonus* species, Jeffrey pine beetles use pheromones that attract other beetles to a tree, causing a mass attack that tends to overcome the tree's natural resistance. Blue stain fungi are associated with Jeffrey pine beetle attacks and aid in overcoming the tree's defenses.

Conditions Affecting Outbreaks

Normally the Jeffrey pine beetle is kept in check by its natural enemies, climatic factors and the resistance of its host. Similar to other *Dendroctonus* species, the availability of suitable host material is a key factor influencing outbreaks. Healthy trees ordinarily produce abundant amounts of resin, which pitches out attacking beetles. When deprived of moisture, or stressed by other factors such as disease or fire injury, trees cannot produce sufficient resin flow and become susceptible to successful beetle attacks.

Fir engraver beetle

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year; however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Heterobasidion root disease

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores

produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion root disease in western North America is caused by two species: *Heterobasidion occidentale* (also called the 'S' type) and *H. irregulare* (also called the 'P' type). These two species of *Heterobasidion* have major differences in host specificity. *H. irregulare* ('P' type) is pathogenic on ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita. *H. occidentale* ('S' type) is pathogenic on true fir, spruce and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentale* being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Black Stain Root Disease

Hosts: Ponderosa and Jeffrey pine, pinyon pine, and Douglas-fir. Lodgepole pine, western hemlock, mountain hemlock, sugar pine and knobcone pine are also susceptible, but damage is rare.

Characteristics: There are three distinct taxonomic varieties (subspecies) of the black stain root disease pathogen. Each variety has a unique set of hosts, and all are found in California. *Leptographium wageneri* var. *wageneri* is pathogenic to pinyon pine; *L. wageneri* var. *pseudotsugae* causes black stain root disease in Douglas-fir; and *L. wageneri* var. *ponderosum* attacks ponderosa, Jeffrey and lodgepole pine, and occasionally sugar pine and hemlock. Black stain root disease is a vascular wilt disease. It kills trees by blocking their water conducting vessels, and can cause substantial mortality. It does not cause decay of root or stem tissue. Colonization of the root system causes a visible decline in the tree crown. Terminal growth is reduced, needles become shorter and chlorotic, the number of needles produced and retained is reduced ("lion's tail" appearance of branches), and finally the host dies. Disease centers appear as small (usually less than 0.04 ha or 0.1-ac) groups of dead and symptomatic trees. Infection centers can sometimes be much larger, especially in ponderosa pine stands. Unless also affected by root rot fungi, trees killed by black stain root disease usually remain standing. Typical infection centers have trees in various stages of decline near the perimeter and dead trees in the interior where infection originated. Trees with black stain root disease are frequently predisposed to bark beetle infestation.

Symptoms and Signs: Black stain root disease is relatively easy to identify in the field. It produces a distinctive dark brown to black sapwood stain in the roots and root crown that sometimes streaks upward into the lower bole. Cross sections of the wood reveal the stain to be in arcs that follow the annual rings. This stain differs from blue stain, which is more bluish, wedge-shaped in cross section, follows the rays, and is associated with beetle galleries throughout the tree. In black stain-infected overstocked pole sized ponderosa or Jeffrey pine stands or understories, a common symptom is numerous haphazardly fallen stems laying in a 'jack-strawed' manner.

Disease Cycle: Infection centers may be initiated by root-feeding bark beetles and weevils that carry fungal spores on their bodies. These insects are attracted to wounds, the roots of fresh stumps, and weakened, low-vigor trees, which may account for the common association of the

disease with disturbances. Infection of pines appears to be favored by wet, cool environments. Local tree-to-tree spread is via infection of small rootlets, following either root contact or short distance growth of the fungus through soil. Disease centers can enlarge at a rate of four to twelve feet per year. Although the fungus can remain for long periods in live host tissue, it is relatively non persistent and is difficult to isolate from previously infected wood much more than a year after the tree dies.

Damage and Importance: Black stain root disease usually is found in areas where there has been significant site disturbance or substantial amounts of tree injury, especially in stands after pre-commercial thinning, along roads, skid trails and landings, on sites with drought-stressed, waterlogged, or compacted soils, or where rotary blade brush cutters have been used to clear roadsides. Certain characteristics are related to black stain root disease in ponderosa pine in the central Sierra. Stands are usually densely stocked and consist of either pure or predominantly ponderosa pine. The largest and most rapidly expanding disease centers are often in cool, low lying sites with high soil moisture levels in the spring. In recent years, black stain root disease has been detected in many new areas, often causing locally severe damage. Incidence appears to be steadily increasing. While the disease is common in cool, wet, overstocked and disturbed sites, bark beetle-caused mortality of trees that are weakened by *L. wageneri* can likewise be significant during periods of drought and other stress.

Management Strategies: At the present time, there is no effective cure for trees that are already infected, and genetically resistant host genotypes have not been identified. Indications from the few long-term field studies that have been conducted suggest that disease impacts may be minimized by maintaining trees in a vigorous condition with adequate spacing while avoiding disturbance and injury, especially during times of peak beetle activity. Partial cutting to attain these objectives can increase or decrease black stain root disease incidence in a stand, depending on several factors, including the amount of soil disturbance that occurs; the time of year that the partial cutting is performed; the amount of host-to-host root contact that remains; and the amount of damage inflicted on residual trees. Several management actions have been suggested to reduce the establishment of new infections and minimize the effects of the disease where it is already present:

- When establishing new stands in or near areas where black stain has been a management concern, a mix of species should be planted to provide future options for species manipulation.

- When thinning, thin aggressively during each entry, leaving an understocked stand. This will reduce the frequency of harvest entries and associated soil disturbance. Reduced stocking may contribute to disease resilience in a stand because uncrowded trees are more vigorous and less attractive to insect vectors of *L. wageneri* and other bark beetles. Open stands will also have warmer soils that inhibit *L. wageneri* and fewer root contacts between susceptible trees.

- Thin stands as early in the rotation as possible.

- During thinning, favor tree species that are resistant or immune to the locally important variant of *L. wageneri* and remove diseased or weakened trees.

- Whenever possible, leave trees that are not hosts for black stain root disease.

- When host tree species have been removed from an infection center, wait at least two years before replacing with host species.

- Harvest in a manner that minimizes soil disturbance and injury to the roots and boles of residual trees. Sites with soils that are prone to compaction by heavy equipment should not be tractor logged. Where timber harvest occurs, high-lead and skyline yarding would be preferred over tractor logging. If tractor logging is the only option, skid trails should be designated, the area covered by skid roads should be minimized, tree falling should be done to the yarding lead, and yarding should be restricted to the dry season when the risk of serious compaction is reduced. New road

construction through high risk areas should be avoided. If construction occurs or old-roads must be re-opened, injured trees or those covered by side-cast fill should be removed. Efforts should be made to avoid injuring trees to be retained on site. This should preclude the use of rotary-blade brush cutters on roads adjacent to high risk areas.

- If possible, thin when insect vectors are least active, generally from late June to early September, allowing time for roots to dry out by fall. In areas where summer months are dry and droughty, the thinning period may be extended into late September. Late fall thins are not recommended because stumps may still attract insect vectors the following spring.

- Reintroduce frequent low intensity ground fires into the landscape. This will prevent ingrowth of brush or conifers which can stress host trees and create host-to-host root contacts. Monitor post-harvest black stain root disease activity to evaluate the effectiveness of various levels of thinning.